Analyzing four-way sensory data resulting from individual vocabulary profiling of audio:

A comparison between HMFA and PARAFAC2

9th Sensometrics Meeting

2008 July 22nd, Ontario, Canada

NOKIA

Gaëtan Lorho

Nokia Corporation

(gaetan.lorho@nokia.com)

Overview

- Presentation of the 4-way sensory dataset
- Analysis by Hierarchical Multiple Factor Analysis (HMFA)
- Analysis by Parallel Factor Analysis 2 (PARAFAC2)
- Conclusions

Sensory evaluation in the field of multimedia

- Any system/application capturing, processing or reproducing audio/visual material
  - We want to evaluate a system
  - Our stimulus is a media clip ‘interacting’ with this system
  - Number of stimuli = number of systems × number of media clips

Loudspeaker systems

Camera optics systems

Video encoding algorithms

An example of audio sensory profiling

- A sensory evaluation of techniques to reproduce music over headphones
  - 8 ‘systems’ evaluated
  - 3 ‘music clips’ considered

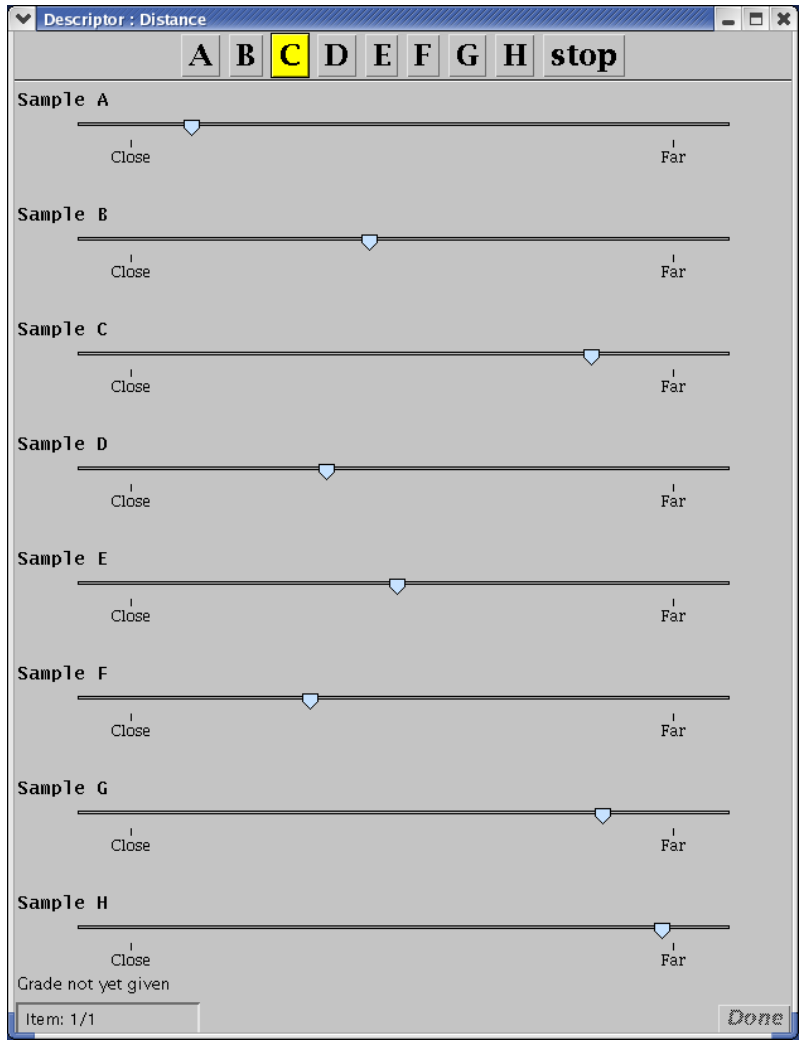
- Sensory profiling inspired by *Flash Profile*
  - Comparative evaluation approach
    - 8 systems for a given music clip

- Outcome for each assessor:

  ⇒ One set of attributes

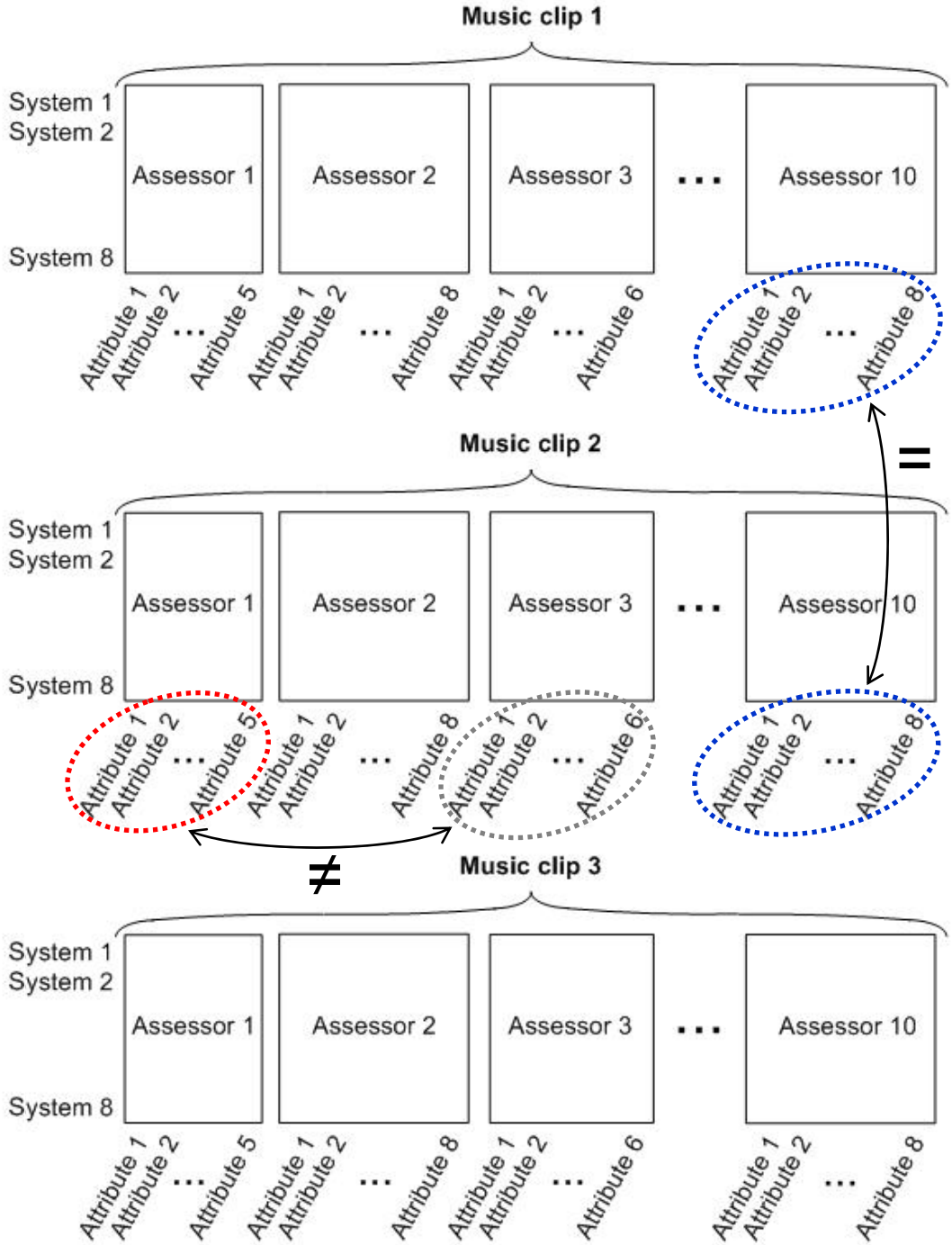
  ⇒ Three sensory profiles

Final attribute scaling UI
One Attribute, One music clip, 8 systems



The resulting four-way sensory dataset

- 8 systems
- 3 music clips
- 10 assessors
- 4 to 8 attributes per assessor



What type of analysis can we apply to that data ?

- Questions of interest:
  1. Underlying sensory characteristics of the set of systems
  2. Differences in characteristics between music clips
  3. Differences between assessors, etc.

- Data analysis methods
  - Only multivariate approaches possible !

  - Usual 3-way methods
    - GPA, MFA, Tucker-1, STATIS, etc.
    - Possible only by unfolding the data

  - We want to preserve the 4-way structure of the data
    - HMFA
    - PARAFAC2

NOKIA

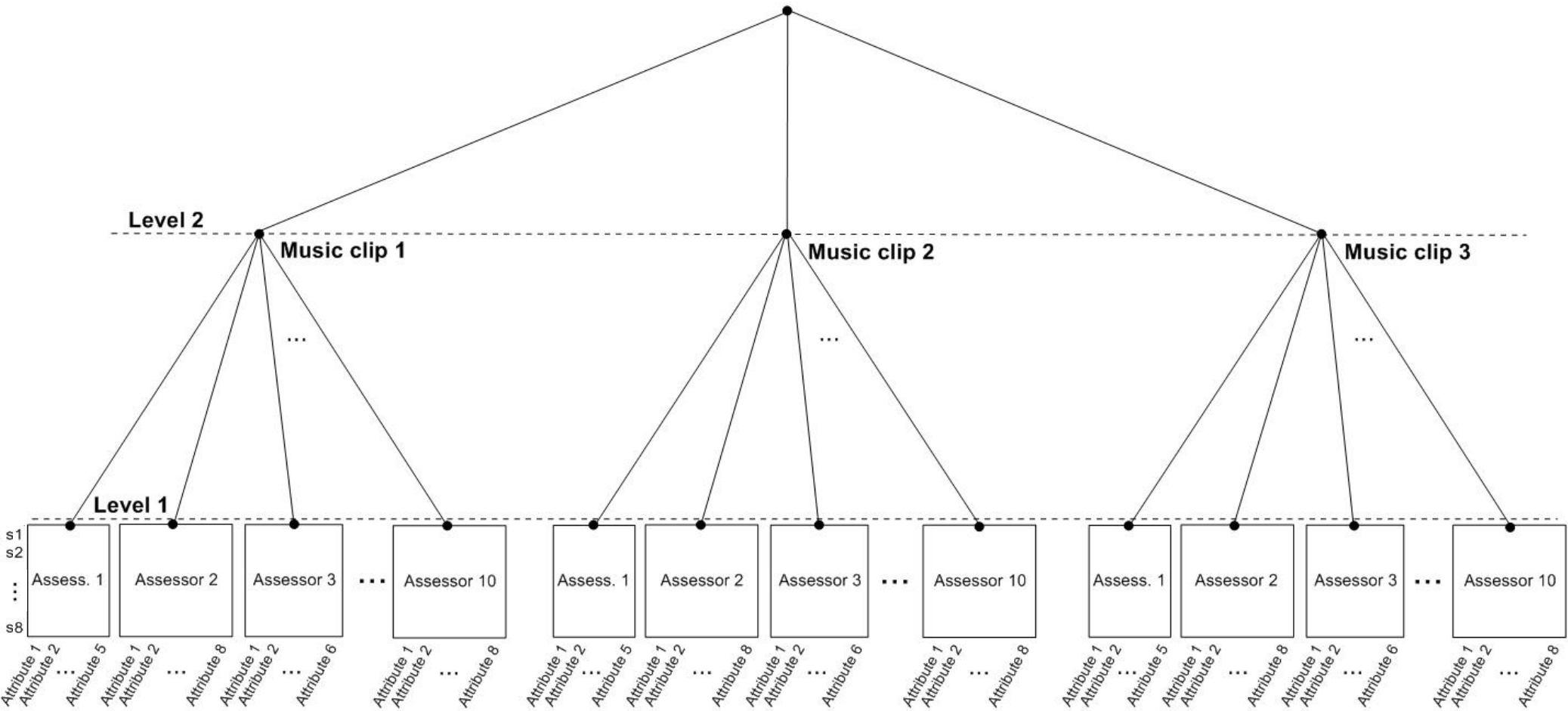
Overview

- Presentation of the 4-way sensory dataset
- Analysis by Hierarchical Multiple Factor Analysis (HMFA)
- Analysis by Parallel Factor Analysis 2 (PARAFAC2)
- Conclusions

NOKIA

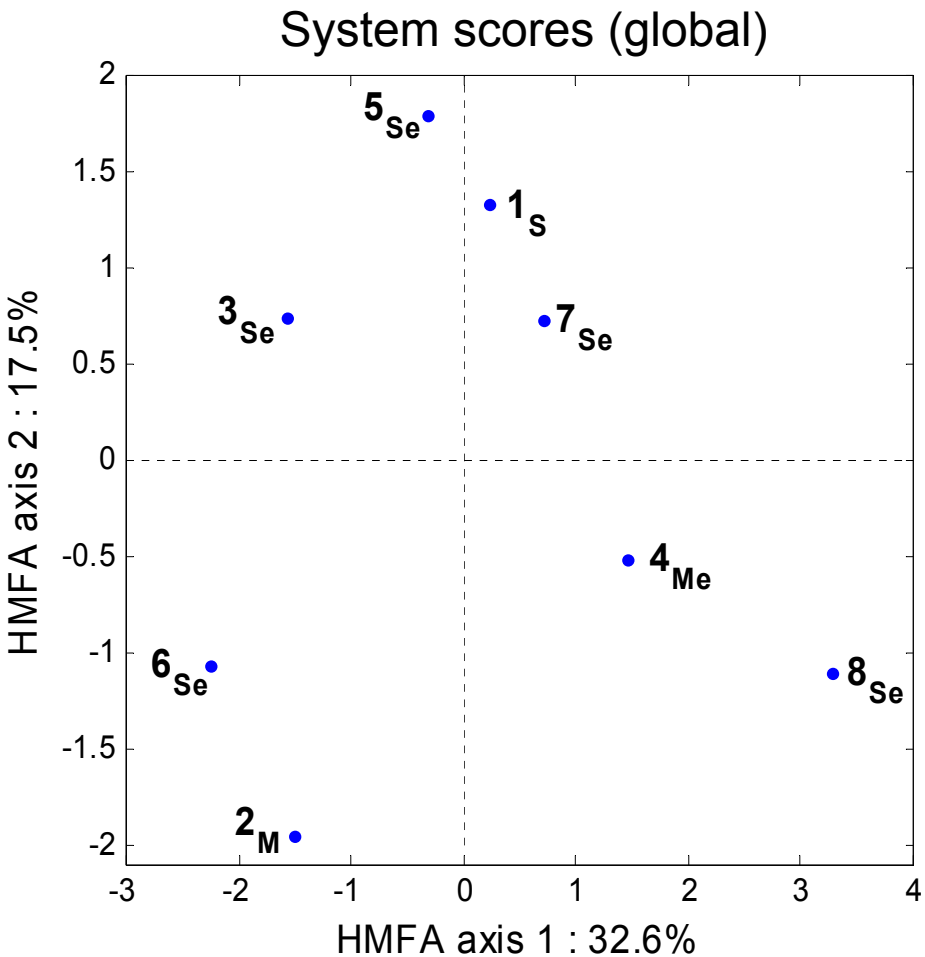
Hierarchical Multiple Factor Analysis

- A hierarchical structure with two levels:
  - Level 1: All individual sensory profiles
  - Level 2: Three different music clips
- Analysis was run with the FactoMineR package in R

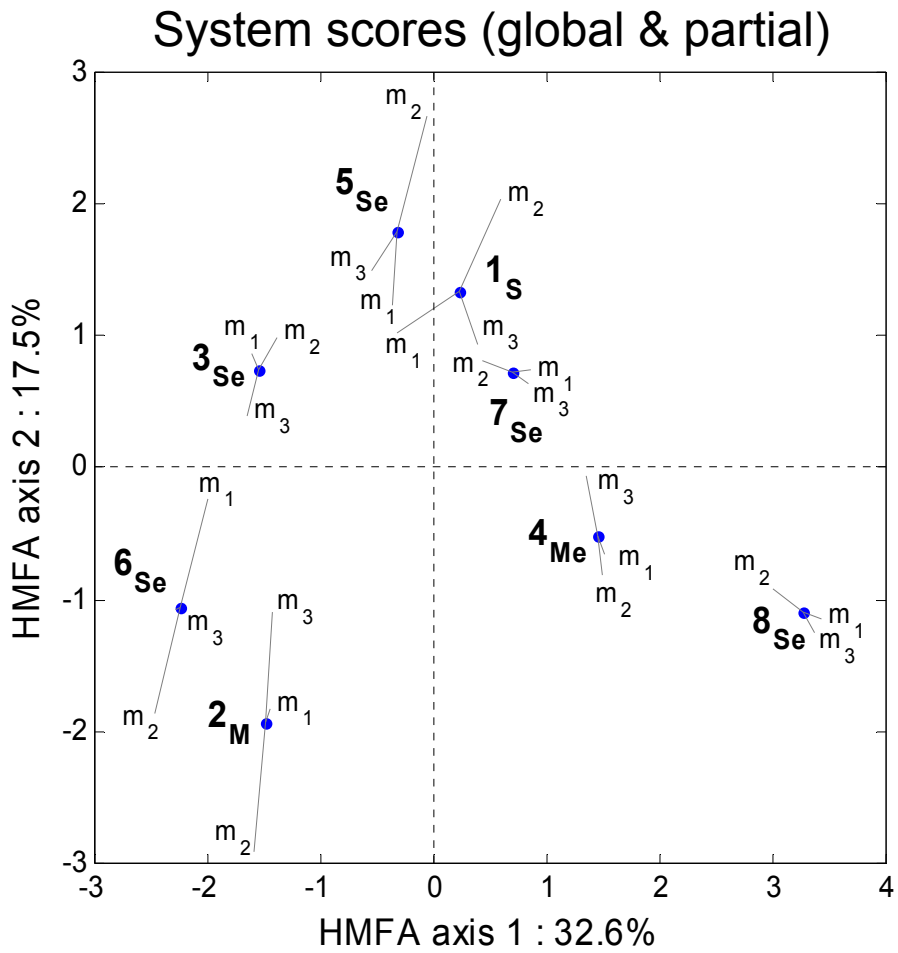


HMFA Results (1)

- Model summary
  - A two-component model is selected
  - 50% of explained variance

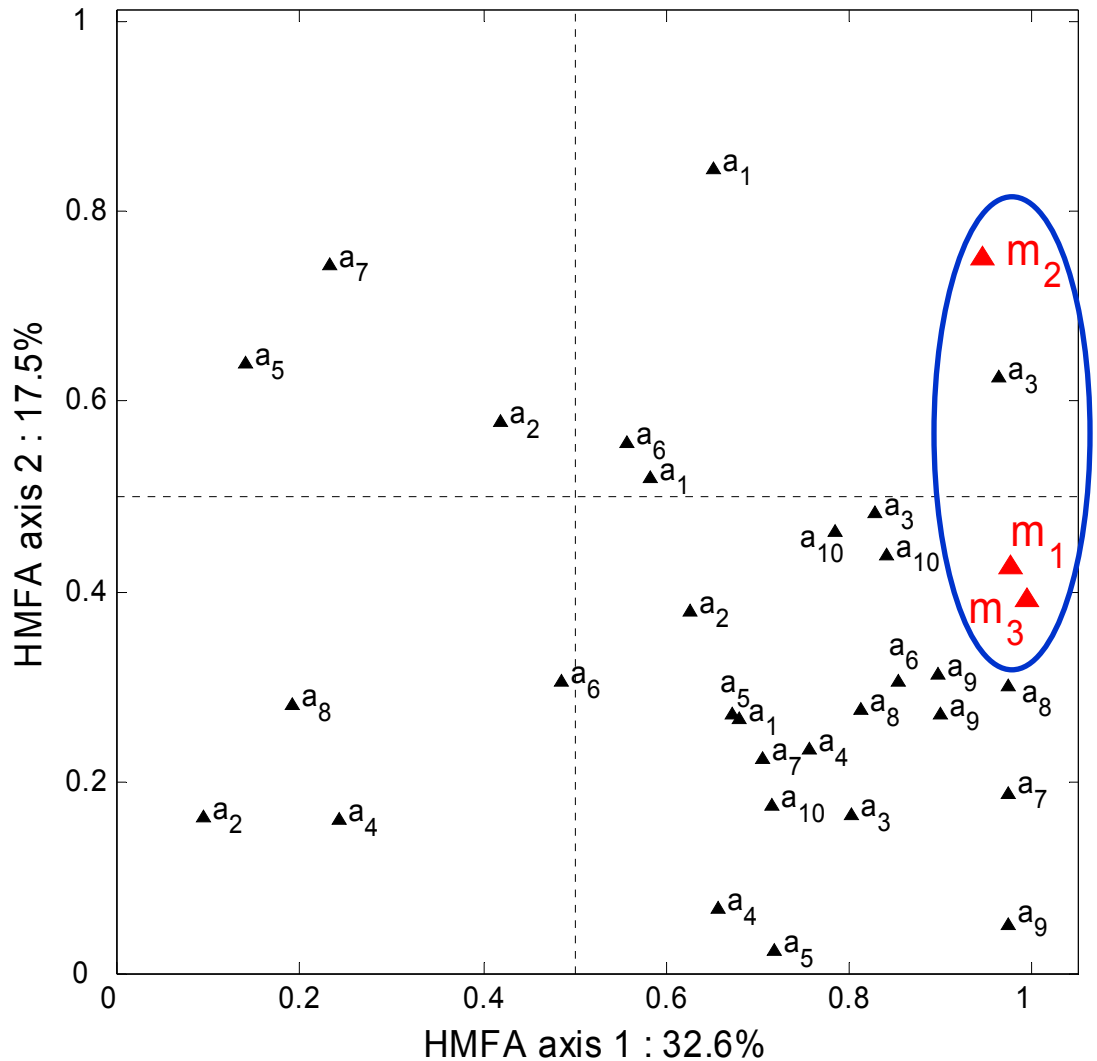


- HMFA scores: Systems
  - Global scores
  - Partial scores



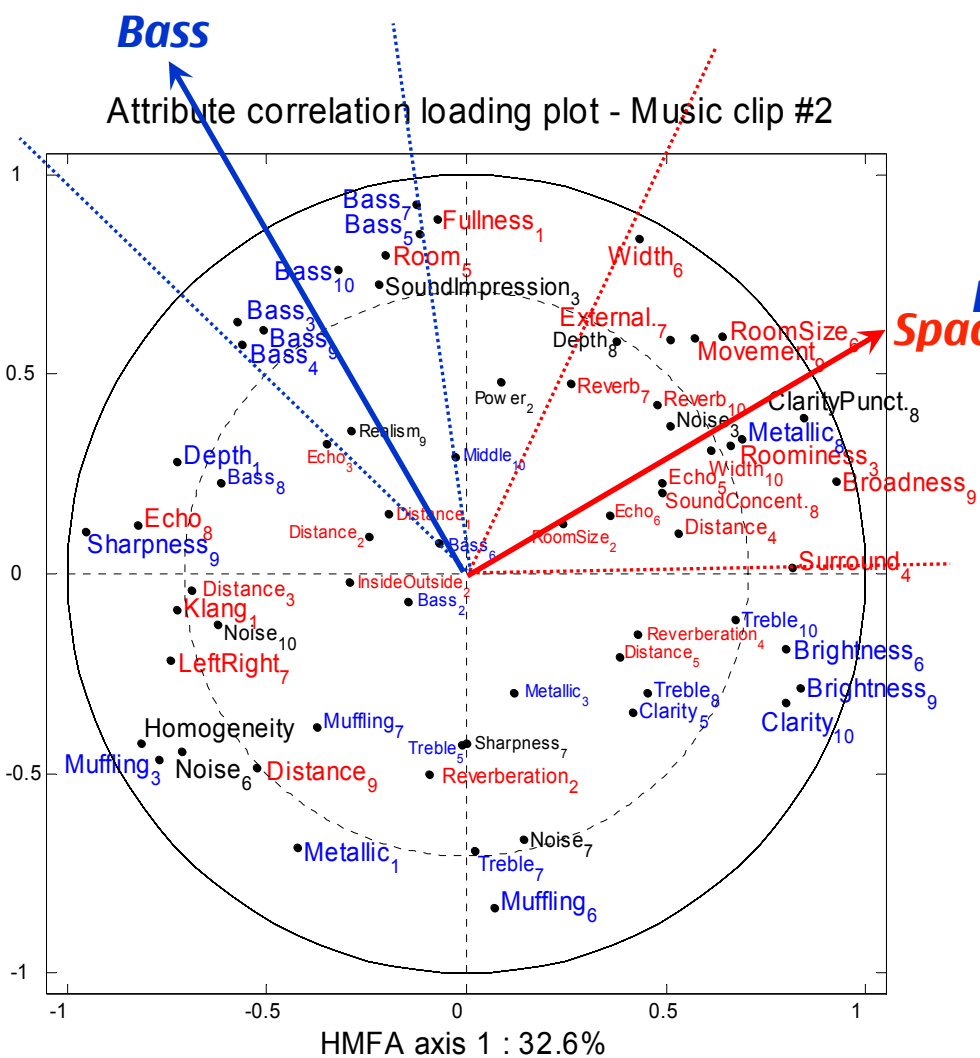
HMFA Results (2)

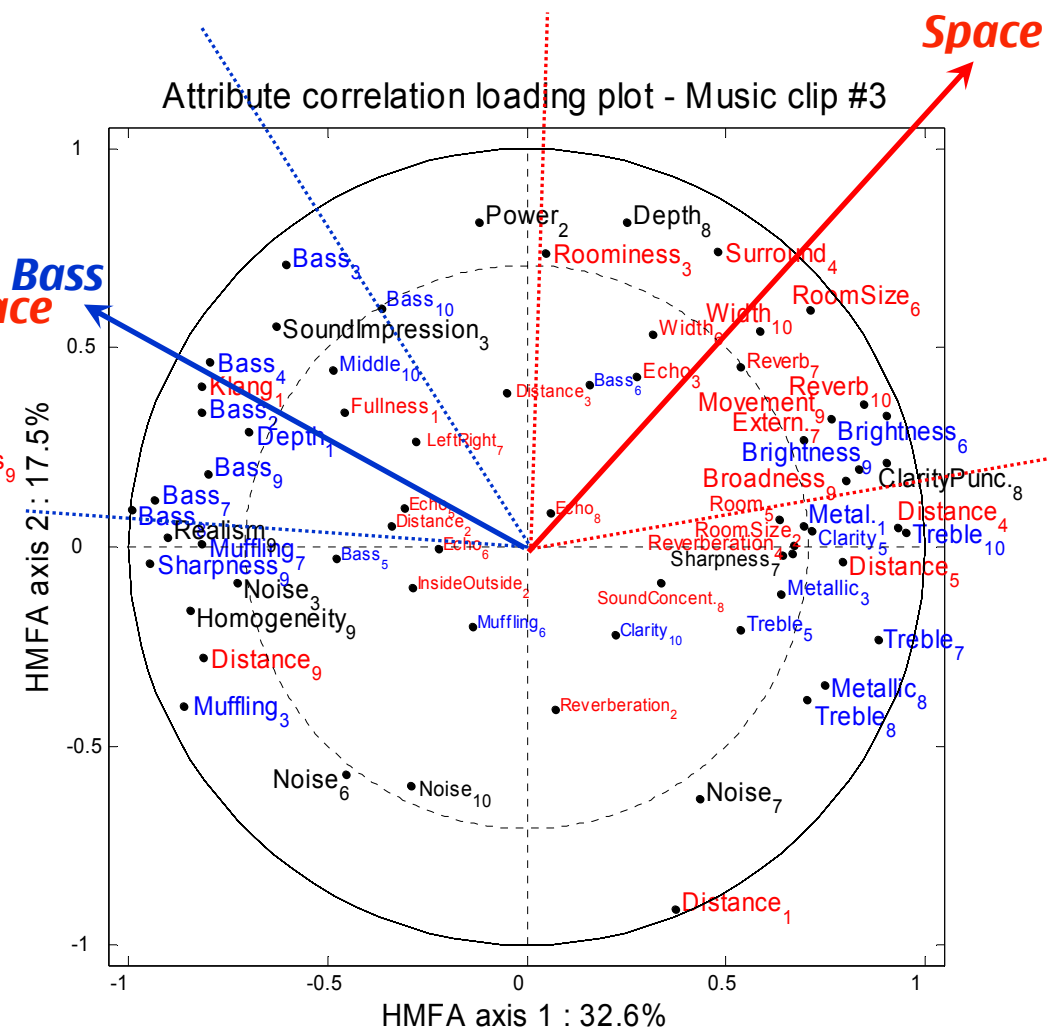
- Relationships between groups of variables and HMFA components
  - First level: 30 sensory profiles
  - Second level: 3 music clips



HMFA Results (3)

- HMFA loadings: 198 attributes !
  - Interpretation is not that straightforward...





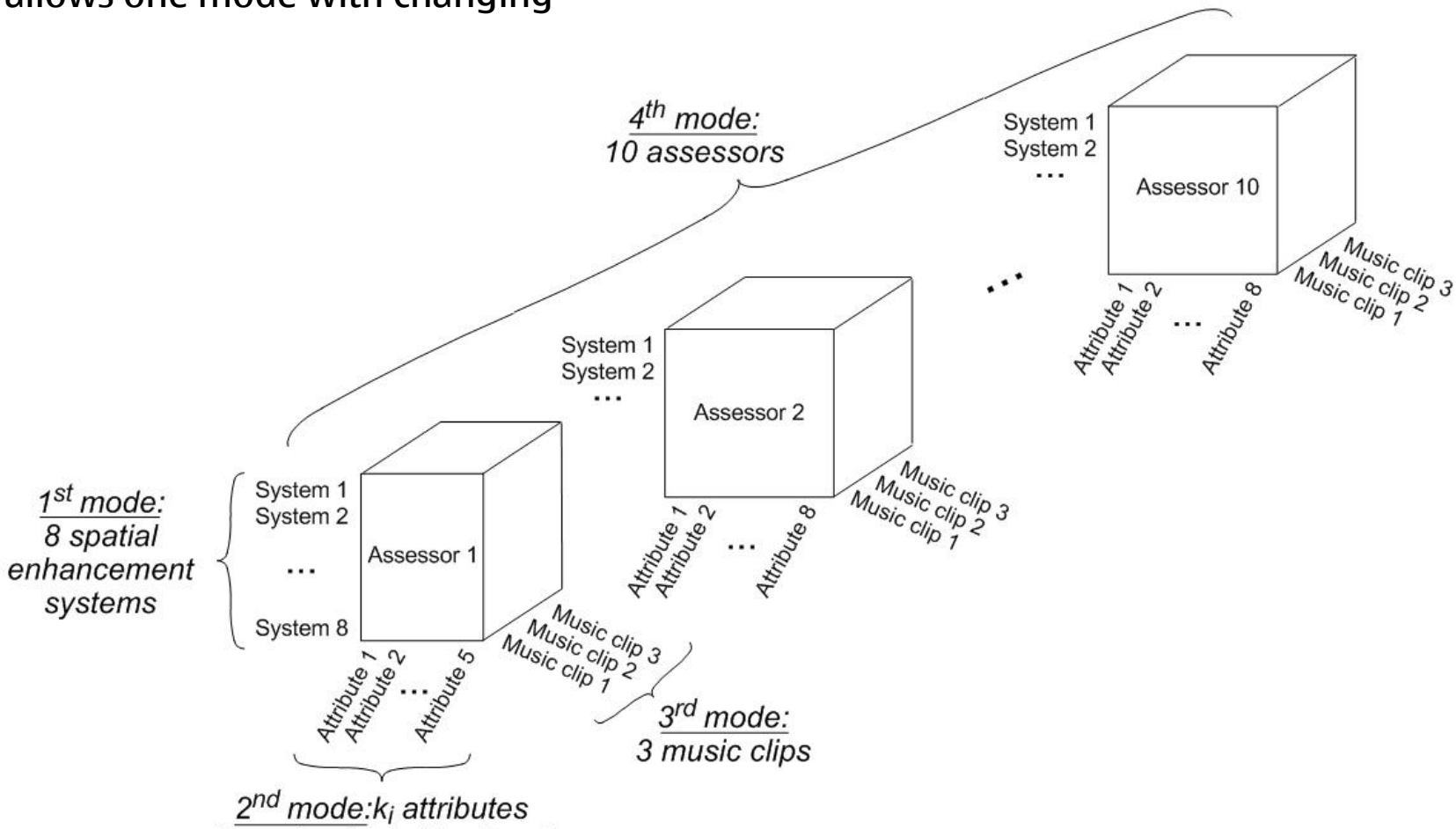
Overview

- Presentation of the 4-way sensory dataset
- Analysis by Hierarchical Multiple Factor Analysis (HMFA)
- Analysis by Parallel Factor Analysis 2 (PARAFAC2)
- Conclusions

NOKIA

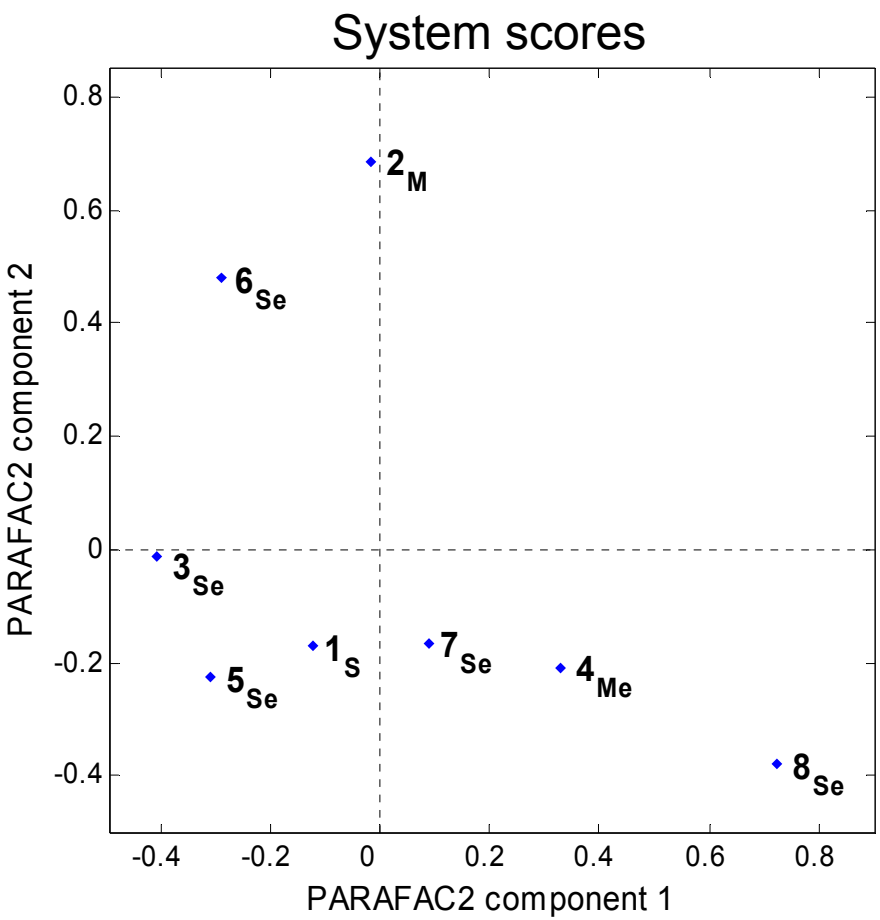
Parallel Factor Analysis 2

- A four-way sensory dataset
  - ⇒ The PARAFAC-based models can handle *n* modes
- Attributes are specific to each assessor
  - ⇒ PARAFAC2 allows one mode with changing variables
- Analysis was run with the PLS toolbox in Matlab

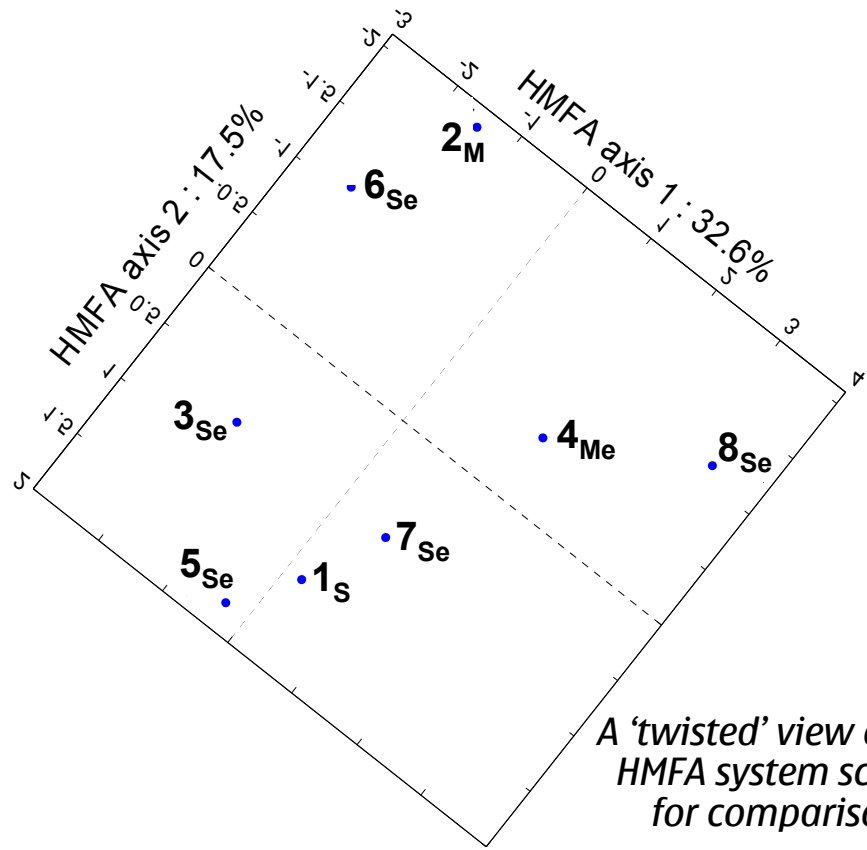


PARAFAC2 Results (1)

- Model summary
  - A two-component model is selected
  - 38% of explained variance



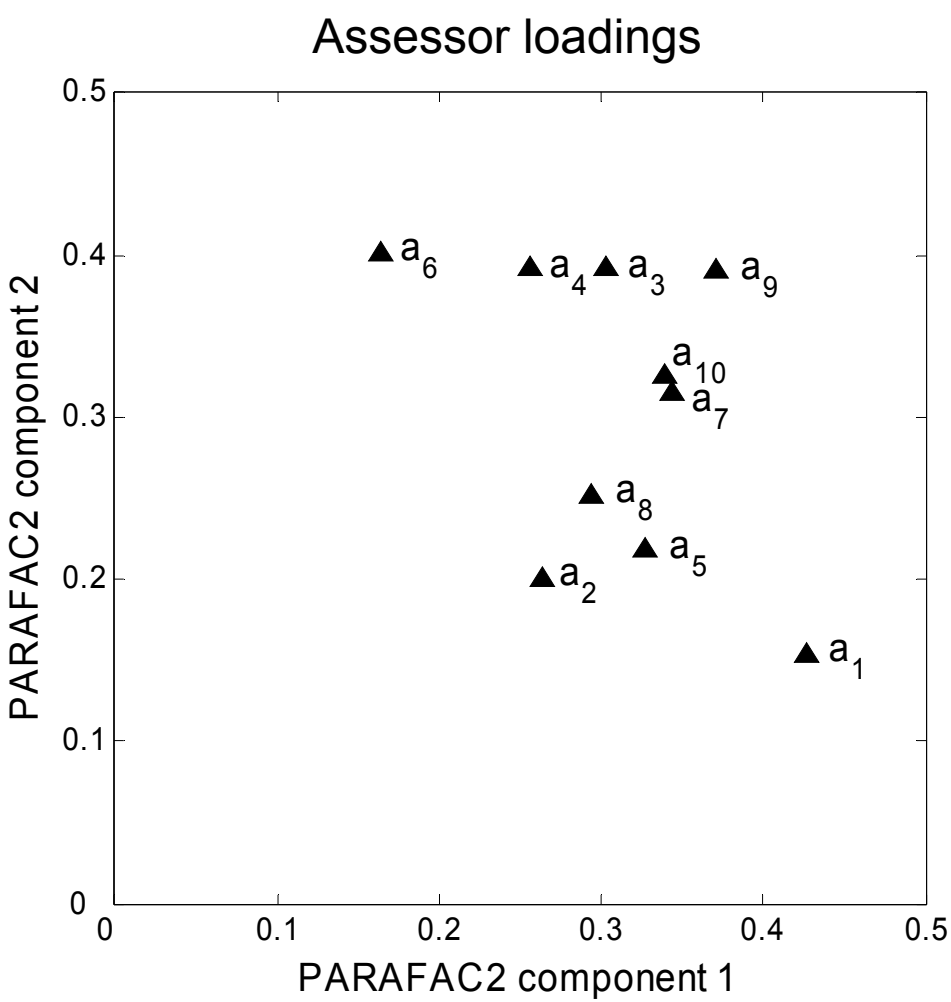
- PARAFAC2 scores: Systems
  - Pattern similar to HMFA overall

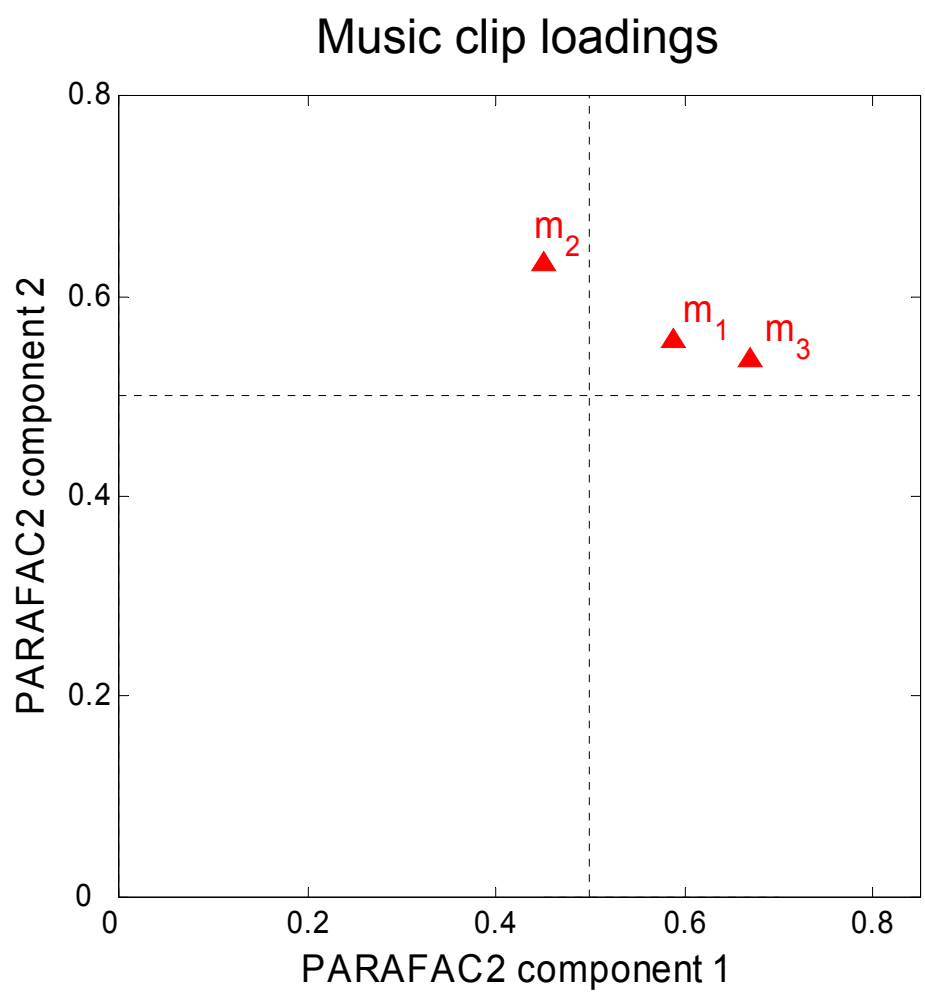


A 'twisted' view of the HMFA system scores for comparison

PARAFAC2 Results (2)

- Separate ‘assessor loadings’ and ‘music clip loadings’

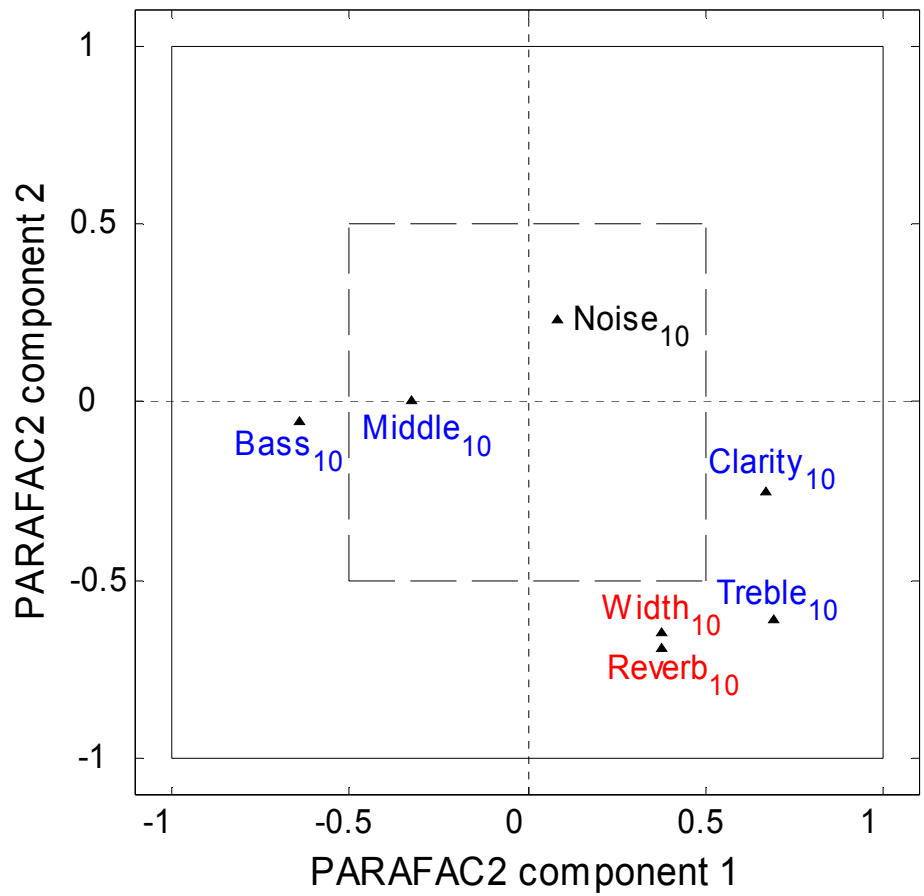




PARAFAC2 Results (3)

- The special mode of attributes
  - One set of attribute loadings per assessor
  - Individual loadings are common to the 3 music clips
  - A multiway version of correlation loadings[1] is used for visualization

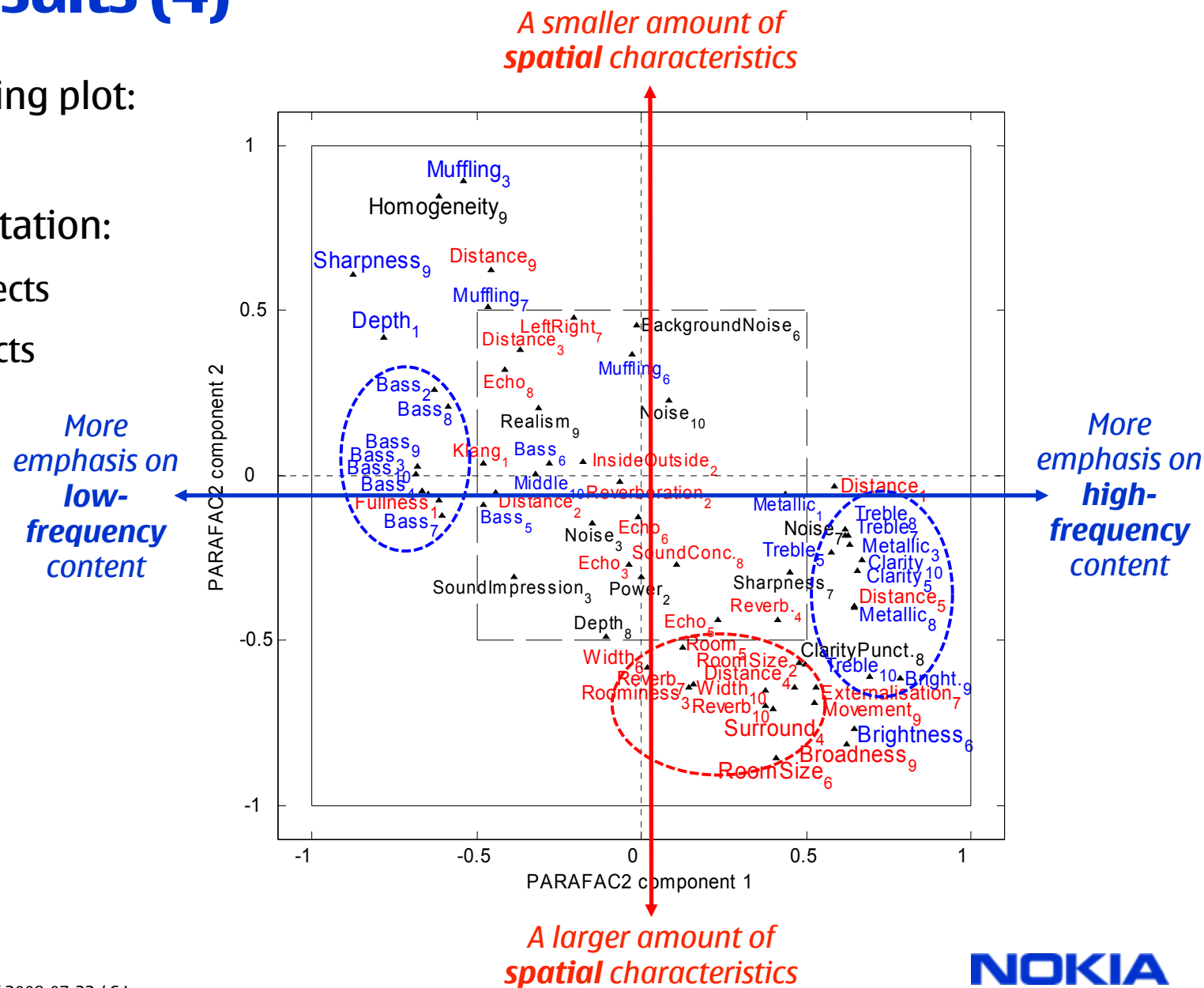
Correlation loading plot – Assessor #10



[1] *Reference: Lorho, Westad and Bro, «Generalized correlation loadings, Extending correlation loadings to congruence and to multi-way models», Chemometrics and Intelligent Laboratory Systems 84, 2006.*

PARAFAC2 Results (4)

- Full correlation loading plot:
  - 66 attributes
- Component interpretation:
  - LV 1: Timbral aspects
  - LV 2: Spatial aspects



Overview

- Presentation of the 4-way sensory dataset
- Analysis by Hierarchical Multiple Factor Analysis (HMFA)
- Analysis by Parallel Factor Analysis 2 (PARAFAC2)
- Conclusions

NOKIA

Conclusions

- Sensory evaluation of an audio application
  - Using the Flash Profile approach
  - Results in a four-way sensory dataset
- HMFA and PARAFAC2 are applicable to this type of data
- These two analysis methods differ but are complementary
  - HMFA
    - Data representation only imposes ‘systems’ to be identical across sensory profiles
    - This offers good flexibility in analysis
  - PARAFAC2
    - Data represented as a four-way array in which different variables are only allowed in one mode (i.e. attributes)
    - This offers a more structured model

NOKIA

Analyzing four-way sensory data resulting from individual vocabulary profiling of audio:

A comparison between HMFA and PARAFAC2

Thanks for your attention

NOKIA

Gaëtan Lorho
Nokia Corporation
(gaetan.lorho@nokia.com)